Meteor-Showers.

	R.A.	Decl.	
Between Lynx and Auriga	98°	46° N.	
Near ν Virginis	175	10 N.	Slow ; bright.
,, κ Cephei	300	80 N.	Slow ; bright.

GEOGRAPHICAL NOTES.

M. ROLLAND, a French naturalist, charged with an official mission to Madagascar, has sent in his Report to the Minister of Public Instruction. M. Rolland sums up his geographical observations by remarking that, notwithstanding its apparently simple contour, the topography of Madagascar is exceedingly complex. Behind the line of lagoons which border the coast, and which, except that the water is salt, remind one of the *étangs* of Languedoc, the hills begin to rise, and increase in height towards the interior. Behind these, again, the mountains rise by stages to a height of over 6500 feet. The surface is cut up by innumerable ravines, at the bottom of which are torrents, which rush on their way towards the Indian Ocean. This chain forms the backbone of the island, and consists mainly of Primary and crystalline rocks. When it is crossed, the Mozambique Channel is reached. The two slopes, east and west, are very unequal in extent. The former, which M. Rolland has explored to a considerable extent, occupies more than one-third of the total area of Madagascar. A broad valley, that of the Mangoro, runs north and south, parallel to the great central chain and the coast. Unfortunately, the Mangoro is not navigable, even for canoes. The two other most important rivers are the Manangoro and the Mangataka ; and these three rivers, with innumerable streams, render this part of the island one of the best-watered regions on the globe. The climate varies considerably from one zone to another. On the east coast the temperature oscillates between 13° and 30° C. ; on the west coast, it never descends below 17° ; in Imerina province it ranges from 5° to 25°. M. Rolland refers in some detail to the well-known characteristics of the fauna of Madagascar, and to the abundance of mineral treasures, especially iron, copper, and lead ; but, he states, the natives carefully conceal the localities of the beds.

LIEUT. VANS AGNEW has undertaken a journey to the Upper Salween and South-Eastern Tibet, with the object of attempting the solution of the problem of the course of the Lu River—whether to the Irawadi or the Salween—propounded by General J. T. Walker in his paper read to the Royal Geographical Society on April 25, 1887. The Council of the Society have sanctioned a contribution of £100 towards the expenses of the expedition. Lieut Vans Agnew leaves India for the Salween in the course of the present month.

AT the February meeting of the Berlin Geographical Society Dr. A. Schenck read a report on his recent journey in Nama Land and Herero Land, South-West Africa. He showed that the whole country between Walfisch Bay and the Orange River is—in consequence of the purely mechanical decomposition of the prevailing granitic rock, which is taking place under the great daily variations of temperature, causing in many places the disintegrated surfaces to be eaten away in the form of a crust—covered over with a sea of sand and granitic shingle, from which the highest elevations stand out like islands. The country is not suited for agricultural colonies. The coast and the interior stand in contrast with regard to the season of rainfall. While on the coast the rain falls mostly in winter, the rainfall in the interior occurs only in summer, and nearly always in the form of thunder-showers, which, as Dr. Schenck believes, are caused by the condensation of the moisture-laden air, which is brought to this part by the warm, humid, north-east winds from the more equatorial regions of Africa, through coming into contact with the cool south-west winds blowing from the coast to the interior. As to the configuration of Great Nama Land, Dr. Schenck gives the following notes. After the hilly coast-region between Angra Pequena and Aos is passed, a broad valley-like depression is reached, filled up with drift-sand. East of the depression the country ascends and forms a stony, desolate plain, out of which rise isolated peaks or longer mountain-chains running in a north and south direction. The whole of this district, as far as Aos, forms a connected mountain system composed of ancient rocks, granite, and gneiss, which has been buried by the sand from which the higher parts stand out. Beyond Aos the traveller enters upon the steppe region, which is divided into detached plateau districts. Beyond Aos and the river-bed of the Goăgib, on which the station of Bethanien is situated, the Huib plateau stretches away to the north, as far as the region of Khuias, and to the south to a point a few miles north of the Orange. A long series of table-mountains, resembling in form truncated cones, mark the western escarpment of this plateau ; the former are composed of granite and gneiss, and are covered with limestone and sandstone, horizontally laid down. East of Bethanien, and corresponding with the line of a long geological fault, is the escarpment of another plateau ; it is about 5000 feet in height. It descends to the Great Fish River on the east ; on the other side of the river, the plateau character of the country is continued to the Karas Plateau, which extends into the brush steppe of the Kalahari. Further details concerning this interesting region will be found in the March number of the Proceedings of the Royal Geographical Society.

THE FORCES OF ELECTRIC OSCILLATIONS TREATED ACCORDING TO MAXWELL'S THEORY. BY DR. H. HERTZ.[1]

II.

Note by the Translator.

IT is to be noted that Hertz follows the French system of wave-lengths and periods. Had I noticed this before the diagrams went to the engraver, I would have altered it, and interpreted his T as ½T, &c., throughout. As it is, I have left them everywhere as in the original. My elaborate attempt to evade a literal translation of *Doppelpunkt* was quite unnecessary. Prof. Karl Pearson has sent me a reference to Maxwell's definition of "double-point" in vol. i. Art. 129, first edition of "Electricity and Magnetism."—O. J. L.

In order now to ascertain the distribution of force for the remaining parts of space we may use graphic representation, constructing for definite times the lines of electric force, viz. the curves $Q =$ const., for equi-distant values of Q.

Since Q itself is the product of two factors, of which one depends only on r, the other only on θ, the construction of these curves presents no great difficulty.

We decompose every value of Q for which we want the curve into two factors in different ways ; we determine the angle θ for which $\sin^2\theta$ is equal to the one factor, and by means of an auxiliary curve that value of ρ for which the function of ρ contained in Q is equal to the other factor ; we thus get as many points as we please of the curve. When one attempts to carry out the construction one perceives many small processes which it would be prolix to detail here. We will content ourselves with examining the results of such construction, as exhibited in Figs. 1, 2, 3, 4.

These figures represent the distribution of force at the times $t = 0, \frac{1}{4}T, \frac{1}{2}T, \frac{3}{4}T$; and also, by suitable inversion of the arrows, for all future times which are similar multiples of $\frac{1}{4}T$. At the origin is shown, in the correct aspect and about of the right proportional size, the arrangement by which in our earlier experiments the oscillations were excited.

The lines of force are not indicated right up to the picture because our formulæ regard the oscillators as infinitely short, so in the neighbourhood of a finite oscillator they are insufficient.

Let us begin a study of the figures with Fig. 1. Here, when $t = 0$ the radiation is in the condition of its strongest development, but the poles of the straight oscillator are not electrically charged—no lines of force start thence. Such lines of force begin, however, now from the time $t = 0$ to start out from the poles ; they are inclosed in a sphere which expresses the value $Q = 0$. In Fig. 1 this sphere is indeed still vanishingly small, but it enlarges itself quickly, and by the $t = \frac{1}{4}T$ it fills already the space R_1 (Fig. 2). The distribution of lines of force inside the sphere is approximately of the same kind as correspond to a static electric charge on the pole. The speed with which the spherical surface $Q = 0$ spreads out from the origin is at first much greater than $\frac{1}{A}$ [or "v"] ; in fact, the latter velocity would only correspond to the distance given in the figure as $\frac{1}{4}\lambda$ for the time $\frac{1}{4}T$. At infinitesimal distance from the origin the velocity of outspreading is indeed infinite.

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[1] Translated and communicated by Dr. Oliver Lodge. Continued from p. 404.

This phenomenon it is which we represented in the old mode of expression by saying that along with the inductive action travelling with the velocity of light there was superposed an electrostatic force travelling with infinite speed.

We properly express this phenomenon in terms of our present theory when we remark that fundamentally the self-forming waves do not arise solely from processes occurring at the origin, but are influenced by the condition of the whole surrounding medium, which latter, according to Maxwell's theory, is the true seat of the energy. However this may be, the surface $Q = 0$ expands with a velocity which gradually reduces to $\frac{1}{A}$, and by the time $t = \frac{1}{2}T$ it fills the space R_2 (Fig. 3). By this time the electrostatic charging of the pole is at its greatest development; the number of lines of force which start thence attains its maximum value.

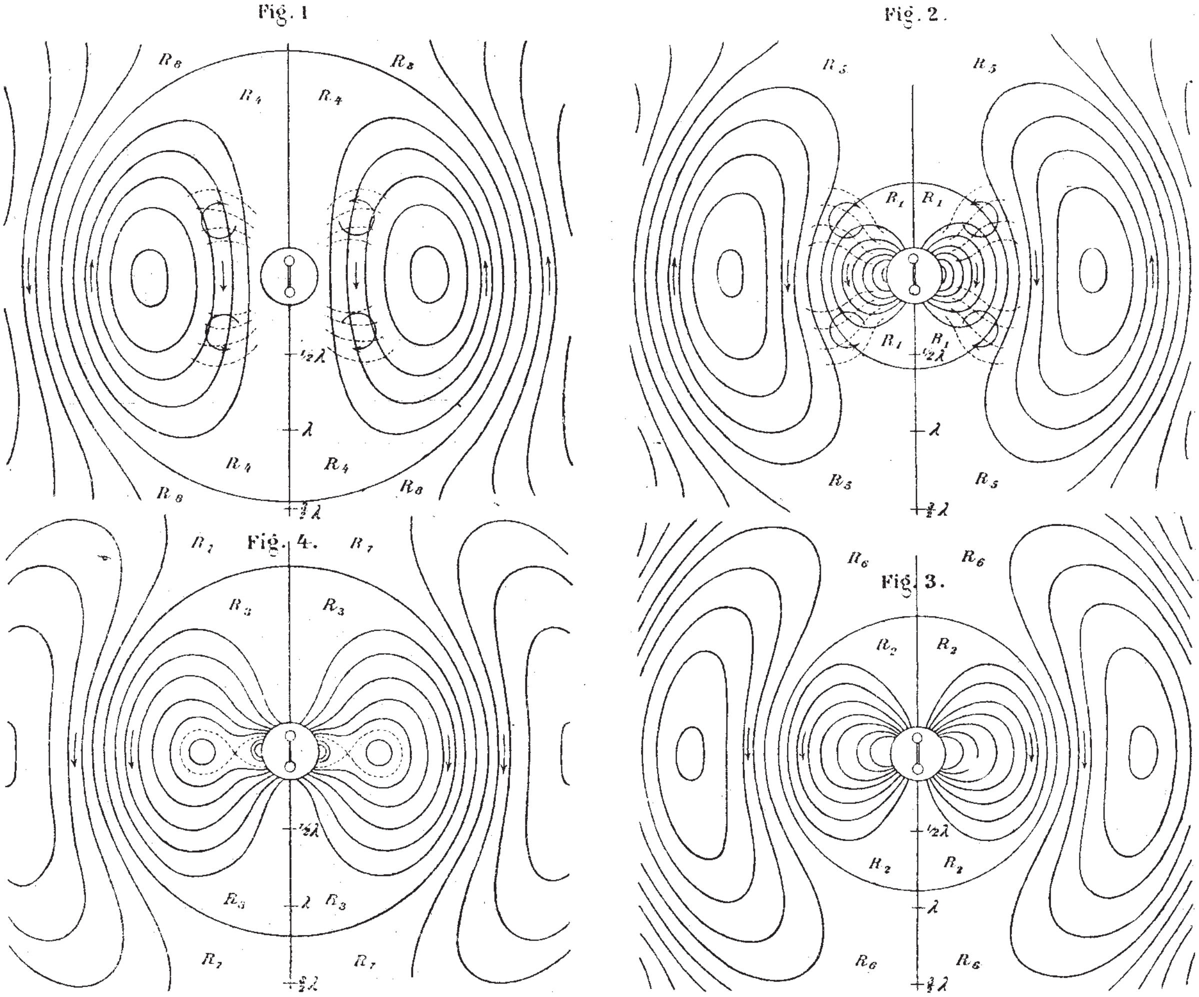
With further increase of time no fresh lines of force protrude from the poles; rather, those already produced begin to withdraw back into the conductor, there to vanish as lines of electric force, their energy, however, being converted into magnetic energy.

Hence occurs a singular behaviour which in Fig. 4 ($t = \frac{3}{8}T$) is plainly to be recognized, at least in its beginning. The lines which have furthest removed themselves from the origin get drawn together by the stress with a lateral inflexion; this inflexion approaches nearer and nearer to the axis of z; and then a self-closed portion detaches itself from each of the outer lines of force, which automatically spread out into space, while the residue sink back into the conductor.

The number of receding lines is just as great as the number of originally expanding lines; their energy, however, is necessarily diminished by the energy of the detached portion. This loss of energy corresponds to the radiation into space. In consequence of it the oscillation must soon come to rest unless some impressed forces restore the energy lost to the source. Meanwhile we have regarded the oscillations as undamped, and thus implicitly understood the existence of such forces.

In Fig. 1, to which we can now return for the time $t = T$, since we can imagine the arrows inverted, the detached portions of the lines of force fill the space R_4, while the lines starting from the poles have completely vanished. But new lines of force break out from the pole, and compress the lines whose early history we have followed into the space R_5 (Fig. 2).

It needs no further explanation now to follow these lines into the spaces R_6, R_7, and R_8. More and more they transform themselves into a pure transverse wave motion, and lose themselves as such in the distance. One would get the best picture of the play of force if one made a series of drawings for still smaller time-intervals, and examined them with a stroboscopic disk.



These figures correspond to successive stages in the history of a semi-oscillation. Ignoring the arrows, Fig. 1 represents the state of things at the end of every half-period; Fig. 3 at the end of every quarter-period; Figs. 2 and 4 represent one-eighth and three-eighths of a complete oscillation respectively. I do not feel clear about the correctness of the straight arrows in Fig. 1.

A closer consideration of the figures shows that the direction of the force changes from instant to instant for such points as lie either in the axis of z or in the plane xy. If we represent the force at a point, therefore, in the customary way by a line, the end point of this line oscillates, not indeed in a straight line, but in an ellipse. In order to see whether there are points for which this ellipse approximates to a circle, in which, therefore, the forces go through all the directions of a windrose without important change of magnitude, let us superpose two of the representations expressing times which differ by $\frac{1}{4}$T; for instance, Figs. 1 and 3, or 2 and 4.

For the points we seek, the lines of the one set must plainly cut those of the other system orthogonally, and the distances of the lines of the one figure must be equal to those of the other. The small quadrangles formed by the superposition of the two systems must therefore be squares for the sought points.

There may be now remarked, in actual fact, a region of the kind sought: it is represented in Figs. 1 and 2 by circular arrows, whose directions give at once the direction of the rotation of the force. The dotted lines are inserted for convenience; they belong to the line system of Figs. 3 and 4.

One finds, moreover, that the force exhibits the behaviour here described, not only at the specified points, but also in the whole strip-formed region which, spreading out from those points, forms the neighbourhood of the z axis. Nevertheless, the magnitude of the force decreases so quickly in these directions, that only in the points above-mentioned can its singular behaviour be important.

The system of forces now described and required by theory can be quite well recognized in an incomplete observation, not hitherto indicated by theory, which I formerly described (*Wied. Ann.* xxxiv. p. 155, 1888). One cannot, indeed, explain everything about those experiments, but one can get the main points correctly.

By both experiment and theory the distribution of force in the neighbourhood of the oscillator is chiefly an electrostatic distribution. By both experiment and theory the force spreads out chiefly in the equatorial plane and decreases in that plane at first quickly, afterwards slowly, without being zero at a mean distance. By both theory and experiment the force, in the equatorial plane, in the axis, and at great distances, is of constant direction and varying magnitude, while at intermediate points it changes its magnitude but little and its direction much. The correspondence between theory and those experiments only breaks down in this, that at great distances, according to theory, the force remains always normal to the straight line through the source, while by experiment it appears to be parallel to the oscillator. For the neighbourhood of the equatorial plane where the forces are strongest this follows from the equations too, but not for directions which lie between the equatorial plane and the axis. I believe that the error is on the side of experiment. In these experiments the direction of the oscillator was parallel to both the main walls of the laboratory, and the component of the force which was parallel to the oscillator might be thereby strengthened in proportion to the normal components.

I have therefore repeated the experiment with a different arrangement of the primary oscillator, and found that with certain arrangements the result corresponds with theory. I did not attain an exact result, but found that at great distances, and in regions of small intensity of force, disturbances due to the boundary of the space available were already too considerable to permit a safe verdict.

While the oscillator is at work, the energy vibrates in and out of the spherical surfaces surrounding the origin. More energy goes out, however, through any spherical surface during an oscillation than comes back; and indeed the same excess quantity goes through all spherical surfaces. This extra quantity represents the loss of energy during the period of swing due to radiation. We can easily calculate its value for a spherical surface whose radius, ρ, is so great that it is permissible to employ a simplified formula. Thus the energy going out of the spherical zone between θ and $\theta + d\theta$ in the time dt will be—

$$2\pi\rho \sin\theta \, \rho d\theta \, dt . \frac{\mathrm{P}}{4\pi\mathrm{A}} (\mathrm{Z} \sin\theta - \mathrm{R} \cos\theta).$$

Putting into this the values of Z, P, and R, which are proper for great distances, and integrating from $\theta = 0$ to π, and from $t = 0$ to T, we get, as the energy going out through the whole sphere during every half complete swing,—

$$\tfrac{1}{3}\mathrm{E}^2 l^2 m^3 n \mathrm{T} = \frac{\pi^4 \mathrm{E}^2 l^2}{3\lambda^3}.$$

Let us try to obtain an approximate estimate of the amount of this corresponding to our actual experiments. In those we charged two spheres of 15 centimetres radius in opposite senses up to a spark length of 1 centimetre about. We may estimate the difference of potential between these spheres as 120 C.G.S. electrostatic units, so each sphere was charged to half this potential, and its charge was therefore E = 900 C.G.S. units.

The total store of energy which the oscillator originally possessed amounted to 60 × 900 = 54,000 ergs, or 55 centimetre-grammes. The length of the oscillators, moreover, was 1 metre approximately, and the wave-length was about 480 centimetres.

So the loss of energy in half a swing comes out about 2400 ergs. It seems, therefore, that after eleven half-swings one-half of the energy must have gone in radiation. The quick damping which the experiments made manifest was therefore necessitated by radiation, and could not be prevented even if the resistance of conductor and spark were negligible.

A loss of energy of 2400 ergs in 1·5/100,000,000 of a second means a performance of work equal to 22 horse-power. The primary oscillator must be supplied with energy at at least this rate if the oscillation is to be permanently maintained at constant intensity in spite of the radiation. During the first few oscillations the intensity of the radiation at about 12 metres distant from the vibrator corresponds with the intensity of solar radiation at the surface of the earth.

(*To be continued.*)

GENERAL EQUATIONS OF FLUID MOTION.

THE general equations of the motion of a fluid can all be comprehended in a single form, which seems to be deserving of special notice.

Taking the ordinary notation, u, v, w, for the velocity-components at any point, P, of the fluid at any instant, and denoting the components of vortical spin at the point by ω_1, ω_2, ω_3, the usual Cartesian equations can be at once put into the form—

$$\frac{du}{dt} + \frac{d}{dx}\left(\tfrac{1}{2}q^2 + \int\frac{dp}{\rho}\right) + 2(w\omega_2 - v\,\omega_3) = \mathrm{X},$$

and two analogues, q being the resultant velocity. If through the point P we draw any curve whatever, the direction-cosines of whose tangent are l, m, n, and multiply the above and its two analogues, respectively, by l, m, n, we obtain by addition the equation—

$$\frac{d\dot{s}}{dt} + \frac{d\mathrm{U}}{ds} + 12\Delta = \mathrm{S} \quad . \; . \; . \; . \; . \; . \; . \; (\alpha)$$

in which $\dot{s}$ stands for the component of velocity along the tangent to the curve, $\mathrm{U} = \frac{1}{2}q^2 + \int\frac{dp}{\rho}$, S = component of external force-intensity along the tangent, and Δ is the volume of the tetrahedron formed by the vector drawn at P to represent q, the resultant velocity, the vector drawn to represent Ω, the resultant vortical spin, and the vector representing a unit length along the tangent to the curve at P. (Strictly speaking, the notation $\dot{s}$ is not a good one, but it is the best that presents itself.)

This equation (α) is that which I propose, as typical of all fluid motion, and as including all the special Cartesian equations in current use.

Some simple results follow at once for the case of steady motion. Thus, if we integrate (α) between any two points, A, B, of the curve,

$$\mathrm{U_B} - \mathrm{U_A} + 12\int\Delta ds = \int \mathrm{S} ds \quad . \; . \; . \; . \; . \; (1)$$

where $\mathrm{U_B}$ and $\mathrm{U_A}$ are the values of U at B and A.

Now, in particular, if the curve drawn at P is a stream-line, $\Delta = 0$ at every point of it; also, if the curve is a vortex-line, $\Delta = 0$ at every point, and we have the simple result,

$$\mathrm{U_B} - \mathrm{U_A} = \int \mathrm{S} ds \quad . \; . \; . \; . \; . \; . \; . \; . \; (2)$$